Chapter 4

QUANTITIES AND CHARACTERISTICS OF POTENTIAL SOURCES OF SCRAP METAL FROM DOE FACILITIES AND COMMERCIAL NUCLEAR POWER PLANTS

This chapter provides quantitative data on the amount of scrap metal potentially available for unrestricted release from nuclear facilities controlled by the Department of Energy (DOE) and from the decommissioning of nuclear power plants. Scrap metal quantities for DOE sources and the means by which the data were developed are discussed in Section 4.1. A comprehensive discussion of scrap metal sources that will be generated from the decommissioning of commercial nuclear power reactors is provided in Appendix A—a summary discussion of these data is presented in Section 4.2. Section 4.3 provides a brief summary of recent recycling activities involving scrap metal from commercial and government-owned facilities.[1]

4.1 EXISTING AND FUTURE SCRAP METAL QUANTITIES AVAILABLE FROM DOE

4.1.1 Background Information

The historic role of DOE was to design, test, manufacture, and maintain nuclear weapons. This effort started with the Manhattan Project and the development of the first nuclear weapons that were employed in World War II.

Shortly after World War II, deteriorating relations between the United States and the Soviet Union led to a massive nuclear arms race. In the United States, the nuclear arms race resulted in the development of a vast research, production, and testing network of Federal facilities that came to be known as the "nuclear weapons complex." During half a century of operations, the complex manufactured tens of thousands of nuclear warheads and test-detonated more than one thousand.

At its peak, this complex comprised 16 major facilities, each with its own mission (Figure 4-1). Weapons production stopped in the late 1980's, initially to correct environmental and safety problems. Subsequently, most of the nuclear weapons activity has been suspended indefinitely.

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[1] The information on DOE facilities is primarily based on data collected through 1998. As mentioned in Section 2.1, DOE currently has a moratorium on the free release of volumetrically contaminated metals and has suspended the unrestricted release for recycling of scrap metal from radiological areas within DOE facilities.

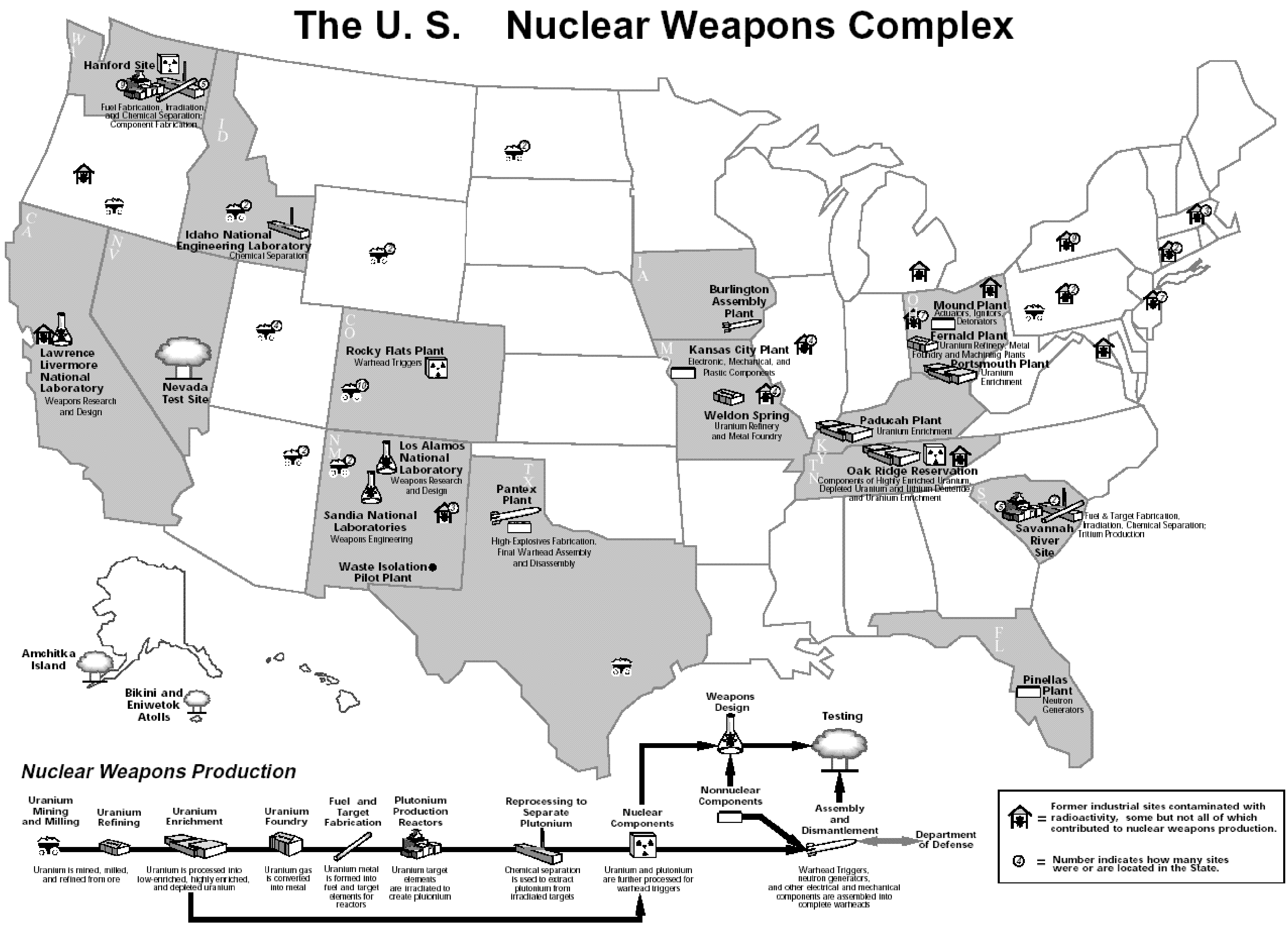

Figure 4-1. Nuclear Weapons Complex (Source: U.S. DOE 1995a)

DOE is now in the process of deciding what should be done with facilities, structures and materials that in many instances are radioactively contaminated. Among the materials that pose significant disposition problems are large quantities of metals that have become radioactively contaminated in various phases of extracting, testing, and producing materials for nuclear weapons.

Radionuclides Associated with Nuclear Weapons

The principal fissile components of nuclear weapons are highly enriched uranium and plutonium. Early nuclear weapons were designed to use either highly enriched uranium or plutonium that, when compressed into a critical mass, would sustain a nuclear chain reaction and result in a nuclear explosion. As designs for nuclear weapons improved, a new generation of thermonuclear weapons evolved that require both plutonium and highly enriched uranium. Thermonuclear weapons also require a third ingredient: tritium, a radioisotope of hydrogen that boosts the explosive power of the nuclear weapon commonly referred to as the hydrogen bomb. The processes by which these three components are produced are the source of radioactive contamination of scrap metals at DOE facilities.

Enriched Uranium. About 99.3% of naturally occurring uranium atoms consists of U-238, almost all of the remaining 0.7% being U-235. However, U-235 is the only naturally abundant uranium isotope that can undergo the sustained fission required for the detonation of nuclear weapons. To make uranium highly enriched in U-235, DOE facilities at the Oak Ridge Reservation in Tennessee initially used two elaborate processes to extract U-235 from natural uranium: (1) electromagnetic separation and (2) gaseous diffusion. However, most of the enrichment was done by the gaseous diffusion process which used uranium hexafluoride (UF_6) gas as the vehicle for enrichment. Additional diffusion plants were subsequently built at Paducah, Ky. and Portsmouth, Ohio.

The enriched UF_6 gas must be converted into a metal before it is used in nuclear weapons production. At the Fernald uranium foundry in Ohio, the UF_6 was chemically converted into uranium metal. Enriched uranium metal was: (1) used as fissionable material in nuclear weapons and (2) fabricated into nuclear fuel for DOE reactors used to produce plutonium.

Between 1944 and 1988, DOE operated 14 plutonium-production reactors at the Hanford and the Savannah River Sites, producing about 100 tons of plutonium. Pu-239 that is required for nuclear weapons is produced by the neutron irradiation of depleted uranium metal targets[2]. Additional weapons-grade plutonium is recovered from the spent fuel of the production reactors.

Unfortunately, both sources also contain hundreds of different radionuclides that must be chemically separated from the fissionable material. Scientists developed elaborate physical structures and chemical processes to accomplish this separation in a manner that is consistent with the safety of workers and the public. A total of eight chemical separation plants, called "canyons," were operated for the DOE. These plants employed the PUREX process for the separation and recovery of plutonium and uranium. In total, the eight chemical separation plants generated more than 100 million gallons of radioactive wastes that are currently contained and stored at DOE facilities.

Sources of Data Used to Quantify and Characterize DOE Scrap

A thorough search for available reports and study data that might contain useful information regarding scrap metal inventories and a characterization of those inventories identified only very limited sources. This was not unexpected when viewed in context of the highly secretive, classified nature of past nuclear weapons activities, the relatively short time since the end of the Cold War, and the yet-undecided future for many DOE facilities.

For these reasons, DOE has only in recent years begun to evaluate existing and future material inventories and their management. Some of DOE's earliest attempts to assess material inventories were based on the most cursory of data; data that were further compromised by an uncertain and continuously revised projection of future needs. Earlier reports are, therefore, of limited value and data reported therein have been revised and updated to reflect the most current information, facility status, and future needs.

The following reports are among the most informative regarding existing and future scrap metal inventories:

1 “A Report of the Materials in Inventory Initiative. Taking Stock: A Look at the Opportunities and Challenges Posed by Inventories from the Cold War Era” (U.S. DOE 1996). (This report is commonly referred to as the "1996 MIN Report" or simply the “MIN Report.”)

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[2] Depleted uranium metal targets are prepared by converting the UF_6 gas that is left after the lighter isotopes—U-234 and U-235—have been extracted by the gaseous diffusion process.

2 “U.S. Department of Energy Scrap Metal Inventory Report for the Office of Technology Development, Office of Environmental Management,” (Parsons et al. 1995). (This report is commonly referred to as the "HAZWRAP Report.")

3 “Scrap Metal Inventories at U.S. Nuclear Facilities Potentially Suitable for Recycling” (SCA 1995a).

4 “Gaseous Diffusion Facilities Decontamination and Decommissioning Estimate Report” (Person et al. 1995).

Collectively, these four documents identified 13 DOE facilities as principal sources of scrap metal. A brief description of each of the thirteen sites is presented below (U.S. DOE 1996).

- **Fernald Environmental Management Project**. Located on 1,050 acres in the southwest corner of Ohio, the Fernald Environmental Management Project (FEMP), formerly known as the Feed Materials Production Center, was constructed in the early 1950's to convert uranium ore to uranium metal targets. Uranium targets were subsequently shipped to DOE production reactors, where targets were irradiated for the production of plutonium used in nuclear weapons. Over a 36-year period, this facility produced over 225 million kilograms of purified uranium. Production of uranium targets ceased in 1989. Principal radioactive contaminants include the uranium isotopes and their radioactive progenies and Tc-99.

- **Hanford**. The Hanford reservation encompasses about 560 square miles within the Columbia River Basin in southeastern Washington and borders the Tri-Cities area of Richland, Pasco, and Kennewick to the south. Nuclear materials were produced at Hanford since the early 1940's. Activities once included plutonium production and separation, advanced reactor design and testing, basic scientific research, and renewable energy technologies development.

- **Idaho National Engineering and Environmental Laboratory**. The Idaho National Engineering and Environmental Laboratory (INEEL) encompasses an area of approximately 890 square miles in southeastern Idaho on the edge of the Eastern Snake River Plain. INEEL is a multipurpose laboratory supporting the engineering and operations efforts of DOE and other Federal agencies in the areas of nuclear safety, reactor development, reactor operations and training, waste management and technology development, nuclear fuel reprocessing, and energy technology/conversion programs. Over 50 nuclear reactors, most of them small test reactors, have existed at INEEL. Some of these reactors and their associated support buildings have been decommissioned and demolished. Others are slated for decommissioning.

- **Los Alamos National Laboratory**. Los Alamos National Laboratory (LANL) occupies about 43 square miles approximately 25 miles northwest of Santa Fe, N.M. LANL was established in 1943 with the specific responsibility of developing the world's first nuclear weapon. The Laboratory's original mission rapidly broadened to include research programs in nuclear physics, hydrodynamics, conventional explosives, chemistry, metallurgy, radiochemistry, and relevant life sciences. In addition to research, a second important mission of the Laboratory between 1945 and 1978 was to process plutonium metal and alloys from nitrate solution feedstock provided by other DOE production facilities. Other operations included reprocessing of nuclear fuel, processing of polonium and actinium, and producing nuclear weapons components. Although the Laboratory has retained many of the original research programs dealing with national defense, its current mission has been expanded to include research in emerging technologies pertaining to biomedicine, nuclear systems for outer space, materials sciences, computational sciences, and environmental management.

- **Nevada Test Site**. The Nevada Test Site (NTS) is 65 miles northwest of Las Vegas and occupies 1,350 square miles, making it the largest facility in the DOE complex. NTS has been the primary site for atmospheric and underground nuclear weapons testing by DOE, with more than 300 nuclear tests conducted above and below ground. This includes tests at NTS and at seven other locations outside Nevada. All nuclear weapons tests at NTS had been conducted underground since 1963. The United States has observed a moratorium on all nuclear tests since 1992.

- **Oak Ridge National Laboratory**. Founded in 1942, the Oak Ridge National Laboratory (ORNL) occupies about 2,900 acres within the Oak Ridge Reservation, which lies south and west of Oak Ridge, Tenn. The Laboratory's original mission was to produce and chemically isolate the first gram quantities of plutonium for use in nuclear weapons. With time, the scope of ORNL greatly expanded to include production of other radionuclides, fundamental research in a variety of scientific disciplines, research pertaining to hazardous and radioactive materials, environmental studies, radioactive waste management and disposal, and a wide range of educational programs.

- **Y-12 Plant**. Built in 1943 as part of the Manhattan Project, the Oak Ridge Y-12 Plant occupies approximately 811 acres within the Oak Ridge Reservation. This facility consists of some 250 buildings that house about seven million square feet of laboratory, machining, and research and development areas. The initial mission of the Y-12 Plant, which began operation in November of 1943, was the separation and enrichment of U-235 from natural uranium by an electromagnetic separation process. When gaseous diffusion technology became the accepted process for uranium enrichment, the magnetic separators were taken out of service in 1946. Since that time, the Y-12 Plant's mission has shifted to the disassembly of returned weapons components, quality evaluation for the existing stockpile of nuclear weapons, and research in engineering designs associated with the production and fabrication of nuclear weapons components.

- **ETTP**. The East Tennessee Technology Park (formerly known as the Oak Ridge K-25 Site) occupies about 1,500 acres within the Oak Ridge Reservation. The K-25 Gaseous Diffusion Plant was built as part of the Manhattan Project to supply highly enriched uranium for nuclear weapons production. Construction of the primary K-25 building started in 1943 and the plant was fully operable by August 1945, with additional buildings involved in the enrichment process brought on stream by 1956. Beginning in 1964, exclusive production of highly enriched uranium for weapons was gradually replaced with the production of commercial-grade, low-enrichment uranium for the emerging nuclear power industry. Because of the declining demand for enriched uranium, the K-25 Plant was placed on standby in 1985 and was permanently shut down in 1987.

- **Paducah**. Located just outside Paducah, Ky., the Paducah Gaseous Diffusion Plant site occupies approximately 750 acres of Federally-owned land. The plant was constructed in the early 1950s for the purpose of enriching uranium by the gaseous diffusion process. Since 1991, both Paducah and Portsmouth have produced only low-enriched uranium for use as fuel in commercial nuclear power plants. In 1993, production operations at both gaseous diffusion plants were assumed by the United States Enrichment Corporation (USEC), a government corporation formed under the Energy Policy Act of 1992.

- **Portsmouth**. The Portsmouth Gaseous Diffusion Plant, located in Piketon, Ohio (approximately 22 miles north of Portsmouth and 75 miles south of Columbus) is situated on 3,714 acres of federally-owned land. In spite of the then-existing gaseous diffusion programs at the K-25 facility and at Paducah, the Portsmouth facility was built to meet the demand for highly enriched uranium created by the emergence of nuclear submarine reactors and for low-enriched uranium for projected commercial nuclear power reactors. In June 2000, USEC announced plans to shut down enrichment operations at the Portsmouth plant in June 2001 (Bechtel Jacobs 2001).

- **Rocky Flats**. The Rocky Flats Environmental Technology Site (RFETS) covers 11 square miles located approximately 16 miles northwest of Denver. Its primary mission was to produce nuclear weapon components, which involved plutonium handling and fabrication. Currently, activities at RFETS include cleaning up contamination and waste from its past activities and converting its facilities to alternative uses.

- **Savannah River Site**. The Savannah River Site (SRS) is located in west-central South Carolina and has an area of approximately 310 square miles; its production facilities occupy less than 10% of the total area. SRS was established by the Atomic Energy Commission in 1950 for the purpose of producing Pu-239 and tritium for nuclear weapons. SRS also produced other special radionuclides (Cf-252, Pu-238, and Am-241) to support research in nuclear medicine, space exploration, and commercial applications. To produce these nuclides, metal targets were irradiated in the five production reactors. The radionuclides were recovered from irradiated targets at chemical separation facilities also located at SRS. Current operation of chemical process facilities is limited to the recycling of tritium and the extraction of Pu-238 for use in space exploration.

- **Weldon Spring**. The Weldon Spring Site consists of 229 acres, approximately 20 miles west of St. Louis, and comprises the Weldon Spring Chemical Plant and the Weldon Spring Quarry. It was part of a site used by the U.S. Army as an ordnance works in the 1940s. In the 1950s and 1960s, the Atomic Energy Commission processed uranium ore in the Chemical Plant. The plant was subsequently deactivated and no further activities were carried out at the site since remediation began in 1985.

Relevant data contained in these four documents are briefly summarized below. Estimates of scrap metal quantities and limited qualitative data are defined in terms of (1) existing scrap metal inventories and (2) projected scrap metal inventories associated with future decommissioning of DOE facilities.

Because significant gaps in quantitative information remain, an attempt was made to supplement reported data by direct contact with DOE personnel. Individuals contacted included key members of the administrative staffs at DOE Headquarters and DOE Regional Offices, as well as personnel in DOE field offices. Field personnel included individuals with responsibilities related to scrap metal decontamination, segregation, storage, environmental monitoring, and salvage and recycling operations. In most instances, direct contacts yielded only subjective information that explained the approach and general methods used to arrive at the reported quantities of scrap metal.

4.1.2 Existing Scrap Inventories at DOE

Data Reported in 1996 MIN Report

DOE's first major undertaking to evaluate its materials management practices dates back to January 1990 with the establishment of the Mixed Waste and Materials Management Workgroup. To support the Workgroup effort, an attempt was made to define and inventory Materials Not Classified As Waste (MNCAW) and resulted in the 1994 MIN Report (formerly known as the MNCAW Report). This and other reports have been combined and collated with new data and analysis to provide information presented in the 1996 MIN Report (U.S. DOE 1996).

DOE defines "materials in inventory" as materials that are not currently in use (i.e., have not been used during the past year and are not expected to be used within the coming year) and that have not been set aside for national defense purposes. The Department identified ten categories with significant quantities of materials. The ten categories are divided into two subcategories: nuclear materials and non-nuclear materials. Scrap metal and equipment are listed in the non-nuclear materials subcategory (Table 4-1).

Table 4-1. Groupings of DOE Materials in Inventory

Nuclear Materials	Non-Nuclear Materials
Spent Nuclear Fuel	Sodium
Plutonium and Other NMMSS- Tracked Materials	Lead
Natural and Enriched Uranium	Chemicals
Depleted Uranium	Weapons Components
Lithium	Scrap Metal and Equipment

Scrap metal consists of worn or superfluous metal parts or pieces including, but not limited to, structural steel and other metals from decommissioned buildings, scrap metals accumulated from facility maintenance and renovation in the past, and scrap stored in scrap yards and lay-down yards. Scrap metal includes metals that are clean and metals radioactively contaminated or activated and/or contaminated with hazardous substances. Equipment considered in the MIN Report is defined as all equipment used for construction, production, or manufacturing, and all associated spare parts and hand tools.

To estimate scrap material inventories, the Department recruited personnel from each DOE Operations and Field Office and from designated Headquarters Offices. The MIN Scrap Metal and Equipment Team sought information by means of site-specific surveys and, whenever possible, extracted information contained in various DOE databases. MIN data collection was, therefore, constrained by the need to use existing data sources; the project team was neither authorized nor allocated resources to conduct new studies or to develop new information. The report acknowledges its limitations and states:

> ". . . Because of limited data, this report does *not* attempt to capture the exact amount of each material in inventory. Rather, it attempts to capture the *general* magnitude of the inventory of each material [emphasis added]."

Despite its acknowledged limitations, the 1996 MIN report is regarded as the principal data source for scrap metal estimates for most DOE facilities. Table 4-2 summarizes these data, as well as presenting estimates for several facilities which were not listed in the MIN Report but represent interpolated values.

Interpolation was needed because only a few DOE sites provided complete quantitative estimates that defined existing scrap metal inventories as clean or radioactively contaminated. Many facilities either provided only a partial breakdown or no breakdown with regard to quantities of contaminated versus uncontaminated scrap metals. In fact, the largest percentage of DOE scrap metal (~80%) reported in the 1996 MIN Report is designated as "unspecified" with regard to radioactive contamination. For scrap metal inventories designated as "unspecified," it was assumed that 88% of scrap metal was contaminated and 12% was clean and not considered contaminated. The basis for this assumption is Table 1-6, page 16 of Volume 2 of the 1996 MIN Report.

Table 4-2 shows that about 90% of the contaminated scrap in existing stockpiles is currently located at five sites. In descending order, they are: Paducah, K-25, SRS, Y-12, and Portsmouth. Information on contaminants identified at each site is also included in Table 4-2.

Data Extracted from the HAZWRAP Report (Parsons et al. 1995)
In 1994, Martin Marietta Energy Systems, Inc., in support of the DOE's Hazardous Waste Remedial Actions Program (HAZWRAP), conducted a study that assessed scrap metal inventories and their economic values for 11 DOE facilities. Collection of information on amounts and locations of scrap metal within the DOE complex was pursued through three independent but complementary methods.

A preliminary questionnaire was forwarded to key site personnel, which requested generic demographic data pertaining to scrap metal management along with a “DOE Scrap Metal Data Sheet.” Key information sought by the questionnaire included (1) type of material (e.g., steel, aluminum, copper, etc.); (2) “radioactivity”, and (3) quantity.

A second source of information for developing estimates in the HAZWRAP Report came from a thorough review of published reports and DOE databases. A total of 28 documents were identified as pertinent.

Table 4-2. Existing Scrap Metal Inventories at DOE Sites

DOE Site	Reported Quantity[a] (tons)	Contaminated		Identified Contaminants
		Fraction[b]	Mass (t)	
FEMP	5,115	0.895	4,161	not specified
Hanford	416[c]	1	378	not specified
INEEL	2,300	0.348	727	fission products on stainless steel, not specified on carbon steel
LANL	0	—	0	
NTS	331	0	0	
ORNL	1,411	0.88	1,129	Cs-137, Sr-90, Co-60
Y-12	11,332	0.88	9,066	not specified
K-25	36,699	0.88	29,359	U+ progeny, Tc-99, Pu-239 (trace), Np-237 (trace)
Paducah	60,473	0.88	48,378	same as K-25
Portsmouth	11,143	0.88	8,914	same as K-25
RFETS[d]	—	—	—	
SRS	15,533	0.934	13,189	H-3, Co, Eu, Cs-137, Am-241, Sb-125
Weldon Spring[e]	—	—	—	not specified
Fermilab/ANL-W/BNL	7,448	0.995	6,722	activation products at Fermi Lab
Pantex/WIPP	393	0	0	
Ashtabula	70	0	0	
SLAC	17	0	0	
Total	152,681		122,023	

Source: U.S. DOE 1995b

[a] U.S. DOE 1995b, Table 1-1

[b] U.S. DOE 1995b, Table 1-3, or, if not specified, 88% is assumed contaminated per Table 1-6, Note 2

[c] Hanford scrap is not included in U.S. DOE 1995b, Table 1-1, but is noted as contaminated "mixed" scrap on p. A8-3.

[d] No available data

[e] ROD calls for on-site burial (U.S. DOE 1995b, p. 10)

Lastly, the HAZWRAP Project Team visited the sites and met with personnel to examine storage areas and document the locations and amounts of stored scrap metal. Confirmatory estimates of stored scrap metal quantities were based on physical measurements of size and storage density of piles.

Scrap metal estimates reported in the HAZWRAP Report were either used directly or updated for the 1996 MIN Report. As indicated in Table 4-2, scrap metal data for LANL, RFETS, and the Weldon Spring facilities were not fully discussed in the 1996 MIN Report. A brief description of the management and current inventories of scrap metals at these three sites, as reported in the HAZWRAP Report, is presented below.

Los Alamos National Laboratory. LANL has an active scrap metal recycling program. Existing scrap metal inventories are stored at several locations in small piles, the largest of which is about 1,800 t. The total quantity of contaminated scrap metal at LANL is estimated to be 3,099 t.

Rocky Flats. At RFETS, contaminated scrap metal is stored in metal drums and boxes that were inventoried in the Site Waste Management database. Because the material quantities could not be determined using the methods described previously, information from the Waste Management Program was used to quantify amounts and metal types of scrap inventories. The total amount of contaminated scrap metal was estimated to be 24,543 t.

Weldon Spring. At the Weldon Spring Site, scrap metal is located in two storage areas. Contaminated scrap metal removed in the past from process piping associated with the Quarry and the Chemical Plant is stored in the Temporary Storage Area and in an eight-acre laydown area called the Material Storage Area. A total of 27,839 t of contaminated scrap metal was estimated to be stockpiled. Since, according to U.S. DOE 1995b, p. 10, the Record of Decision for Weldon Spring specifies on-site burial of the waste, this scrap metal is not included in the inventory presented here.

4.1.3 Summary of Existing Scrap Inventories at DOE Sites

Table 4-3 summarizes the current best estimates of contaminated scrap metal quantities stored at DOE facilities. Most of these estimates were derived from data presented in U.S. DOE 1996. The remaining values were derived from information presented by Parsons et al. (1995).

Based on these data, it is estimated that existing inventories of scrap metal comprise about 150,000 t.

Table 4-3. Estimates of Existing DOE Inventories of Contaminated Scrap Metal (t)

DOE Site	Existing Scrap Metal Quantities	
	MIN Report	HAZWRAP Report
FEMP	4,161	
Hanford	378	
INEEL	727	
LANL	0	3,099
NTS	0	
ORNL	1,129	
Y-12	9,066	
K-25	29,359	
Paducah	48,378	
Portsmouth	8,914	
Rocky Flats	Not Reported	24,543
SRS	13,189	
Other	6,722	
Subtotal	122,023	27,642
TOTAL	149,665	

4.1.4 Scrap Metal Inventory by Metal Type

Data collected in support of the HAZWRAP Report provided information regarding the composition of scrap metal inventories. Quantity estimates were provided for seven forms of scrap metal classified as: (1) carbon steel, (2) stainless steel, (3) copper and brass, (4) nickel, (5) aluminum, (6) tin and iron, and (7) miscellaneous, which included lead, monel, and cast iron. These data were reviewed and updated by the MIN Scrap Metal and Equipment Team. Table 4-4 summarizes data reported in the 1996 MIN Report by metal type.

Inspection of Table 4-4 shows that 3,503 t of scrap metal were found to be free of radioactive contamination. Moreover, an estimated 110,042 t, or about 79.5% of existing scrap, had not been assessed for radioactive contamination and were classified as "unspecified."

Table 4-4. DOE Scrap Metal Inventory (t)

Metal	Clean	Contaminated	Unspecified	Total	%	Contaminated		
						Assumed	Total	Scaled[a]
Carbon Steel	1,008	11,437	94,472	106,917	77.2	86,820	98,257	119,232
Nickel	0	0	8,817	8,817	6.4	8,817	8,817	10,699
Stainless Steel	1,435	5,392	959	7,786	5.6	757	6,149	7,462
Aluminum	27	14	5,637	5,678	4.1	1,925	1,939	2,353
Copper and Brass	24	1,483	147	1,654	1.2	145	1,628	1,975
Tin and Iron	227	0	0	227	0.2	0	0	0
Miscellaneous	782	6,537	10	7,329	5.3	9	6,546	7,943
Total	3,503	24,863	110,042	138,408	100.0	98,473	123,336	149,665
Percent	2.5	18.0	79.5	100.0		71.1	89.1	

Source: 1996 MIN Report

[a] Scaling factor = 1.213

In order to characterize the "unspecified" scrap and adjust the totals in Table 4-4 to be consistent with those in Table 4-3, the following procedure was used. The total quantity of contaminated scrap was estimated by applying the following formula to each of the metals in Table 4-4:

$$\text{Assumed Contaminated} = \left[\frac{\text{Known Contaminated}}{\text{Known Contaminated} + \text{Clean}}\right] \times \text{Unspecified}$$

(In the absence of more information, all of the nickel was conservatively assumed to be contaminated.) Using this procedure, 98,474 t of "unspecified" scrap in Table 4-4 were reclassified as "assumed contaminated." The "assumed contaminated" quantities were added to the contaminated quantities of each metal in Table 4-4 to obtain the total amount of contaminated scrap listed in column 8. However, the total contaminated scrap for all metals resulting from this calculation, 123,336 t, is less than the 149,665 t of contaminated scrap for all sites shown in Table 4-3. To account for this discrepancy, each value in column 8 was scaled upward by a factor of 1.213 (149,665 ÷ 123,336 = 1.213). The adjusted inventories are shown in the last column. It should be noted that carbon steel comprises about 80% of the total DOE inventory of contaminated scrap metal.

4.1.5 Scrap Metal from Future Decommissioning

During peak periods of activity, the nuclear weapons complex included more than 120 million square feet of building structures (U.S. DOE 1995a). These buildings include 14 large production reactors with extensive support structures, research reactors and their associated support structures, eight chemical processing plants with vast quantities of metal piping, tanks, valves, motors, ductwork, and structural components, and an array of buildings used for storage, milling, manufacturing, testing, assembly, and administrative activities.

With the end of the Cold War Era and the reduced demand for additional nuclear weapons, many of these structures will be decommissioned over the next several decades. As of June 1995, DOE's Office of Environmental Restoration Decommissioning Inventory slated 865 structures for future decommissioning (U.S. DOE, Office of Environmental Restoration Decommissioning Inventory, June 1995).

Several facilities are still awaiting final notification of deactivation and are not yet designated for decommissioning. As a result, assessments aimed at estimating future scrap generation at some DOE sites have not been conducted for these facilities.

Site-Specific Estimates

For those DOE sites that are slated for partial or total decommissioning, scrap quantities are at best preliminary estimates that are based on limited and incomplete data. Projected scrap estimates associated with future decommissioning activities were derived from three reports that include the following sites:

- 1995 SC&A Report (SCA 1995a): FEMP, Hanford, LANL, Rocky Flats
- 1996 MIN Report: INEEL, SRS
- 1995 ORNL Report (Person et al., 1995): K-25, Paducah, Portsmouth

Combined scrap quantities from future decommissioning activities at these sites are estimated to be 925,000 t. Scrap sources and site-specific estimates for the nine sites are briefly summarized below.

Hanford. To date, only modest attempts have been made to assess future scrap quantities pertaining to decommissioning activities. However, quantities are expected to be substantial. As of June 1995, 250 buildings at Hanford had been slated for decommissioning. Massive amounts of structural steel scrap will be produced during the decommissioning of these buildings. Also included are other structures such as exhaust stacks, storage tanks, and river outfall structures as well as carbon steel and stainless steel pressure vessels from the Clinch River Breeder Reactor program.

Approximately 91,798 t of scrap are likely to be generated during decommissioning activities. The vast majority of scrap is expected to be carbon steel with significant amounts of stainless steel, lead, and aluminum. The total scrap includes about 100 t of graphite, which is not included in the present analysis.

Idaho National Engineering and Environmental Laboratory. Over the past 50 years, more than 50 nuclear reactors (mostly small test reactors) have operated at INEEL. While some of these reactors and their support buildings have already undergone decommissioning, others are targeted for future decommissioning. Many published DOE documents that cite scrap estimates were assessed in SCA 1995a and in the 1996 MIN Report. Future decommissioning activities at INEEL are estimated to generate 33,785 t of surface-contaminated scrap metal. At this facility, carbon steel (55.7%) and stainless steel (44.0%) constitute nearly all the projected contaminated scrap metal. There are also 337,644 t of uncontaminated, non-activated carbon steel at the site and 472 t of activated steel (U.S. DOE 1995b, p. A3-2). In the present analysis, it was assumed that activated steel would not be a candidate for unrestricted release.

Los Alamos National Laboratory. LANL's Metal Inventory Report (LANL 1996) not only assessed existing scrap metal inventories but identified future scrap metal quantities associated with decommissioning activities, as well as for scheduled "upgrade" projects. In combination, decommissioning and upgrade activities are estimated to generate a total of 2,686 t of scrap.

Fernald. The FEMP production area includes 20 process facilities and supporting structures that are obsolete and beyond their design life. In total, 128 buildings and 72 miscellaneous structures have been designated for decontamination and decommissioning. The dismantling of buildings, process equipment, and structures is estimated to generate 135,623 t of scrap.

Savannah River Site. SRS includes five heavy water production reactors that were used in the production of tritium and other weapon materials. All reactors have been shut down and, at present, there are no scheduled restart dates. Scrap associated with the decommissioning of the five production reactors and support structures/systems is estimated to be 3,463 t with nearly equal contributions from carbon steel and stainless steel. The fate of the two SRS chemical separation plants and the many facilities that support them remains undetermined. The decommissioning of these facilities would undoubtedly add substantial (but to date undefined) quantities of scrap.

Rocky Flats. A literature search in support of SCA 1995a revealed the existence of only one study that estimated future scrap quantities for Rocky Flats. A study by the Manufacturing Sciences Corporation (Floyd 1994) stated that the decommissioning of Rocky Flats is expected to generate about 1,003 t of scrap metal from four buildings that were to be cleaned up by the National Conversion Pilot Project and an additional 25,300 t from the other buildings and site structures. Most scrap is likely to be contaminated with depleted uranium, enriched uranium, and/or plutonium.

Oak Ridge, K-25 Facility. The K-25 facility is the first of three DOE gaseous diffusion plants that are slated for decommissioning. Decommissioning of the K-25 site is estimated to take a total of eleven years: two years of planning and nine years of decontamination and decommissioning. Decommissioning activities are currently projected to be completed in the year 2006 (Person et al. 1995, Fig. 2).

Decommissioning will include removal of large quantities of metals associated with process equipment, piping, and structural components. Principal contaminants include uranium isotopes and their radioactive progenies, Tc-99, and trace quantities of Np-237 and Pu-239. A total quantity of 406,372 t of recyclable metal was listed by Person et al. (1995) but the report did not specify the fractions of uncontaminated and contaminated scrap metal.

Subsequently, personal communications with Gary Person (1996) yielded the following estimates: of the total future inventory of 406,273 t of scrap metal, 193,666 t are estimated to be free of contamination and about 212,706 t are likely to be residually contaminated scrap that is considered suitable for unrestricted release.

Portsmouth. Decommissioning of the Portsmouth gaseous diffusion facility is scheduled to begin in FY 2007 (following completion of decontamination and decommissioning activities at the K-25 facility), with a completion date in FY 2015 (Person et al. 1995, Fig. 2). The decontamination and decommissioning of the three gaseous diffusion plants are purposely scheduled in series in order to (1) learn from experience, (2) minimize annual expenditures, and (3) provide a steady stream of metal for recycle. The availability of 312,085 t of total scrap metal was reported by Person et al. (1995). Of this quantity, 189,072 t were estimated to be contaminated metal that, after decontamination, could be suitable for unrestricted release.

Paducah. The Paducah Gaseous Diffusion Plant will be the third such facility to be decommissioned. Decommissioning is currently projected to start in 2015 and end in 2023 (Person et al. 1995, Fig. 2). The first major phase will be the removal and decontamination of major components (i.e., motors, cell housing, compressors, converters, piping and valves, electrical equipment, and HVAC systems) from the process buildings. Person (1996) said that of the total projected scrap metal inventory of 331,365 t (Person et al., 1995) about 230,886 t are estimated to be scrap that is considered suitable for unrestricted release.

4.1.6 Summary and Conclusions Regarding DOE Scrap Metal Inventories

At its peak, the nuclear weapons complex consisted of 16 major facilities that included buildings with a combined area of more than 120 million square feet. These buildings contain large quantities of equipment, structural steel, and other metal components. Over a 50-year period, some of these buildings, their ancillary facilities, and the equipment they housed have been renovated, replaced, and/or demolished. Currently, about 150,000 t of residually contaminated scrap metal that is considered suitable for unrestricted release is stored at various facilities.

Estimates of existing scrap metal quantities are mostly based on site-specific reviews of historical inventory data and physical surveys of scrap piles; these estimates can therefore be viewed with reasonable confidence.

Future scrap quantities are closely linked to projected decommissioning activities at DOE sites that make up the nuclear weapons complex. At some sites, virtually all structures and their contents will be dismantled and removed; at other sites decommissioning may be limited, and the DOE will continue selected operations considered crucial to national security or important to research. To date, decisions and commitments for decommissioning are not only incomplete but, in instances where such decisions have been made, they remain both tentative and subject to change in scope and schedule. Consequently, estimates of future scrap quantities are uncertain.

In the present report, future scrap estimates were based on currently scheduled decommissioning activities at nine facilities: FEMP, Hanford, INEEL, LANL, SRS, Paducah, Portsmouth, Y-12, and K-25. Decommissioning of these facilities is estimated to yield more than 925,000 t of contaminated scrap metal that is derived from dismantling large production reactors, research reactors, chemical processing plants, and a vast array of associated support facilities and structures. With effective decontamination, this scrap metal is potentially available for unrestricted release.

Table 4-5 provides summary estimates that represent *existing* scrap inventories and *future* scrap associated with decommissioning activities. It is important to remember that the information in this table is for contaminated scrap only. Of approximately one million tonnes of scrap, about 85% is carbon steel, while copper, nickel, aluminum, and stainless steel constitute virtually all of the remainder. It is possible that these values may underestimate the total scrap metal quantities because data pertaining to future decommissioning activities are incomplete.

In the fall of 2000, DOE made a data call requesting information from field locations on current scrap metal inventories and projected scrap metal generation from decommissioning activities through 2035. The data call was designed to support a feasibility study on a dedicated steel mill to process DOE scrap into containers for DOE use (Geiger 2001). As a consequence, materials not suitable for steelmaking because of economic or radiological reasons were eliminated from the database. The data call was confined to carbon steel, iron, stainless steel, and nickel (a key alloying element in stainless steel). Table 4-6 presents a comparison of information from the 2000 data call with corresponding data from Table 4-5.

While there is some shift between carbon steel and stainless steel, the amounts of ferrous metals from the two analyses are remarkably similar.

4.2 SCRAP METAL FROM THE COMMERCIAL NUCLEAR POWER INDUSTRY

At the end of 1997, the U.S. commercial nuclear power industry included 104 operating reactors and 27 reactors[3] formerly licensed to operate (see Appendix A1). Over the next two to three decades, most of the reactors currently in operation will have reached the expiration date of their initial 40-year operating licenses. However, as stated in Chapter 2, NRC has granted 20-year

[3] Only 17 of these reactors are anticipated to release significant quantities of scrap metal (see Section A.5.2.2).

extensions of the operating licenses of five reactors; a number of other renewal applications are pending, and more applications are anticipated. A great deal of data has been compiled by the NRC and the individual utilities regarding the decommissioning of these facilities and the quantities and characteristics of the scrap metal that would be generated in the process. Appendix A presents a detailed summary of the relevant information; an abbreviated version is provided in this section.

Table 4-5. Existing and Future Contaminated Scrap Metal at DOE Facilities (t)

Site Name	Scrap Metal Database	Metal							
		Aluminum	Carbon Steel	Stainless Steel	Copper/ Brass	Nickel	Monel	Lead	Other/ misc.
FEMP	139,780	---	101,740	---	38,040	---	---	---	---
Hanford	90,724	684	87,020	787	5	24	---	291	1,913
INEEL	34,511		19,018	15,449	44	---	---	---	---
LANL	5,785	40	5,568	177	---	---	---	---	---
ORNL	1,129	18	992	117	2	---	---	---	---
Y-12	9,066	34	8,392	602	38	---	---	---	---
K-25	242,065	7,988	232,955	753	304	---	65	---	---
Paducah	279,264	21,161	212,921	190	198	44,794	---	---	---
Portsmouth	197,986	6,130	191,412	18	408	---	18	---	---
RFETS	50,846	---	33,666	2,454	14,726	---	---	---	---
SRS	16,651	14	10,213	6,413	11	---	---	---	---
Other	215	1	---	---	214	---	---	---	---
Total	1,068,022	36,070	903,897	26,960	53,990	44,818	83	291	1,913
Percent	100.00	3.38	84.63	2.52	5.06	4.20	0.01	0.03	0.18

Note: Restricted to metal whose disposition may be affected by a future release standard.

Table 4-6. Comparison of Estimates of Ferrous Metal and Nickel Inventories (1000 t)

Material	2000 Data Call[a]	Pre-2000 Estimates[b]	Difference
Carbon Steel & Iron	792	904	14.1%
Stainless Steel	158	27	-82.9%
Nickel	34	45	32.4%
Total	984	976	-0.8%

[a] Geiger 2001
[b] Table 4-5

A key factor affecting the quantity of scrap metal and associated contamination levels is the basic design of the reactor. The two types of reactors operating in the United States are the pressurized water reactor (PWR) and the boiling water reactor (BWR). Of the 104 reactors operating in the United States, 35 are BWRs manufactured by General Electric and 69 are PWRs manufactured by Westinghouse, Combustion Engineering, and Babcock and Wilcox. Between 1976 and 1980, two studies were carried out for the NRC by the Pacific Northwest National Laboratory (PNNL) that examined the technology, safety, and costs of decommissioning large reference nuclear power reactor plants. Those studies, by Smith et al. (1978) and Oak et al. (1980), for a reference PWR and reference BWR, respectively, reflected the industrial and regulatory situation of the time. To support the final Decommissioning Rule issued in 1988, the earlier PNNL studies have been updated by Konzek et al. (1995) and Smith et al. (1994). These four reports, along with several other NRC reports and selected decommissioning plans on file with the Commission, represent the primary source of information used to characterize Reference PWR and BWR facilities and to derive estimates of scrap metal inventories for the industry as a whole.

4.2.1 Estimates of Contaminated Steel from Commercial Nuclear Power Plants

Table 4-7 presents summary data on contaminated steel potentially available for clearance. Estimates for the Reference BWR and PWR were derived by summing component mass values cited in Tables A-32/64 and Tables A-65/79, respectively. Estimates for the entire commercial nuclear industry were derived by taking Reference BWR and Reference PWR values and applying plant-specific scaling factors for each operating and formerly licensed reactor (except for those which are in an ENTOMB status or for which DECON is in progress or completed). The row marked "Total" lists the total quantities of steel used to construct each plant. "Releasable" refers to all contaminated steel that is a candidate for release, excluding only steel that is neutron-activated. (This includes metal that would require very aggressive decontamination methods to achieve any foreseeable clearance criteria.) Approximately 600,000 t of contaminated steel may become available over time for unrestricted release. About 80% of the contaminated steel is carbon steel, with stainless steel representing the balance.

The data on contaminated equipment in nuclear power plants is usually presented in terms of areal (surface) activity concentrations. However, as will be discussed in the following chapters, the risk assessments of the recycling of scrap metals are based on specific activities. Converting the areal activities to specific activities involves the average *mass thickness* of the metal, which is given by the following equation:

$$\text{Average Mass Thickness} = \frac{\sum \text{Mass}}{\sum \text{Area}}$$

Table 4-7. Residually Radioactive Steel from Nuclear Power Plants (t)

	Reactor Type						Total Industry		
	PWR			BWR					
	All Steel	Carbon Steel	Stainless*	All Steel	Carbon Steel	Stainless	All Steel	Carbon Steel	Stainless
Rebar		9.35e+05			6.16e+05			1.55e+06	
All Other		1.42e+06			5.48e+05			1.97e+06	
Total	2.50e+06	2.36e+06	1.50e+05	1.24e+06	1.16e+06	7.19e+04	3.74e+06	3.52e+06	2.22e+05
Releasable[a]	2.98e+05	2.38e+05	5.96e+04	2.89e+05	2.31e+05	5.78e+04	5.87e+05	4.69e+05	1.17e+05
Low[b]	7.56e+04	6.05e+04	1.51e+04	9.87e+04	7.90e+04	1.97e+04	1.74e+05	1.39e+05	3.49e+04
Medium[c]	4.12e+04	3.29e+04	8.23e+03	1.35e+05	1.08e+05	2.69e+04	1.76e+05	1.41e+05	3.52e+04
High[d]	1.81e+05	1.45e+05	3.62e+04	5.58e+04	4.46e+04	1.12e+04	2.37e+05	1.89e+05	4.73e+04

* Although data for stainless steel and carbon steel are presented as independent quantities, a significant fraction of stainless steel is unlikely to be segregated as such for the purpose of clearance.

[a] Contaminated steel that can be potentially decontaminated

[b] Low-level contamination: $<10^5$ dpm/100 cm^2

[c] Medium-level contamination: 10^5 — 10^7 dpm/100 cm^2

[d] High-level contamination: $>10^7$ dpm/100 cm^2

The total surface area of all potentially contaminated, recyclable carbon steel scrap was determined by taking the sum of the areas of all the inner surfaces of the contaminated components of the Reference BWR and using a scaling factor (based on the reactor's power rating) to determine the area of each actual BWR. A similar procedure was used to determine the contaminated surface areas of PWRs. The average mass thickness—the sum of the areas of all the components in all the commercial power reactors in the United States, divided by the total mass of the contaminated, recyclable carbon steel scrap that could be obtained from these reactors—is 4.79 g/cm^2 (see Section A.5.2.3). Assuming a density of 7.86 g/cm^3 (the density of plain carbon steel [AISI-SAE 1020]), this corresponds to an average thickness of about 0.61 cm (0.24 inches).

4.2.2 Contaminated Metal Inventories Other Than Steel

There are significant quantities of metals and metal alloys other than steel that may be suitable for recycling, including: (1) galvanized iron, (2) copper, (3) Inconel, (4) lead, (5) bronze, (6) aluminum, (7) brass, (8) nickel, and (9) silver. However, there exist no credible data in the open literature regarding the estimated fractions of these metal inventories that are likely to be contaminated or the extent of their contamination. In the absence of reported data, a reasonable approach is to assume that the contaminated fraction of each of these metals is the same as the contaminated fraction of carbon steel for the Reference BWR and Reference PWR. Justification for this modeling approach is based on the fact that most of these metals exist as sub-components of larger items consisting primarily of carbon steel. From data cited in Appendix A, the ratio of contaminated carbon steel suitable for recycling to that of total plant inventory corresponds to 20% and 10% for the Reference BWR and the Reference PWR, respectively. Applying these values to other metals yields the quantities of recyclable, contaminated metal listed in Table 4-8.

4.2.3 Timetable for the Availability of Scrap Metal from Decommissioning

The *currently operating* nuclear power plants are assumed to have an operating life of 40 years, plus any renewals that have been approved by the NRC. It was assumed for the purpose of this analysis that releases of scrap metal would take place ten years following reactor shutdown. Thus, for an operating reactor, the earliest date for releasing scrap metal is assumed to be 50 years after startup. As noted previously, there are also 27 reactors which were formerly licensed to operate. Some of these have been placed in an ENTOMB status, some have been or are currently being decommissioned under the DECON option, some have elected DECON but have not commenced decommissioning, and some are in a SAFSTOR status. Only reactors which are slated for DECON or which are in a SAFSTOR status are included in this analysis (see Appendix A1). It is assumed that reactors in SAFSTOR would retain that status for 50 years, with releases of scrap metal taking place ten years later.

Table 4-9 summarizes the potential availability of scrap metal, starting with the year 2006, and lists all years during which releases are anticipated. The actual release dates of scrap metal may be later than those listed. First, as mentioned on page 4-19, a number of reactors may receive 20-year extensions to their operating licenses, thereby delaying the projected date of decommissioining. Second, many, if not most, facilities are likely to elect the SAFSTOR decommissioning alternative, thereby delaying releases for up to 50 years.

4.3 RECENT RECYCLING ACTIVITIES (1995 - 1998)

This section briefly summarizes recent scrap metal recycling activities involving scrap from both commercial and government sources. The objective is to provide illustrative information rather than an exhaustive analysis. It should be emphasized that several of the activities described below involved recycle and reuse within the DOE complex rather than free release into normal commercial channels for scrap metal processing.

Table 4-8. Contaminated Metal Other than Steel Potentially Suitable for Clearance (t)

Metal	Reference Facility		Industry		
	BWR	PWR	All BWRs	All PWRs	Total
Galvanized Iron	260	130	8,904	9,354	18,258
Copper	138	69	4,726	4,965	9,691
Inconel	24	12	822	863	1,685
Lead	9.2	4.6	315	331	646
Bronze	5.0	2.5	171	180	351
Aluminum	3.6	1.8	123	130	253
Brass	2.0	1.0	68	72	140
Nickel	0.2	0.1	7	7	14
Silver	<0.2	<0.1	<7	<7	<14

4.3.1 DOE Materials

National Center of Excellence for Metals Recycling (CEMR)
The National Center of Excellence for Metals Recycling was established by DOE at Oak Ridge, Tennessee in October 1997 (AMM 1998). Recent activities of the Center for Excellence are listed below (Bishop 1999).[4]

Weldon Spring Site Remedial Action Project. Two hundred eighteen tonnes of suspected radioactive scrap metals were recycled with a cost avoidance to DOE of $336,000 in FY1998.

ETTP Recycle of Metal Pallets. The East Tennessee Technology Park (ETTP) surveyed and sold 1200 pallets through a public offering. The total mass of the 1200 pallets was 244 t. The associated cost avoidance to DOE in FY1998 was estimated at $912,638.

[4] See Note 1.

Table 4-9. Anticipated Releases of Scrap Metals from Nuclear Power Plants (t)

Year	Carbon Steel	Stainless Steel	Galvanized Iron	Copper	Inconel	Lead	Bronze	Aluminum	Brass	Nickel
2006	4,906	1,227	195	103	18	6.9	3.7	2.7	1.5	0.15
2007	1,169	292	45	24	4	1.6	0.86	0.62	0.34	0.034
2016	5,683	1,421	217	115	20	7.7	4.2	3.0	1.7	0.17
2019	11,522	2,881	444	235	41	16	8.5	6.1	3.4	0.34
2020	9,111	2,278	355	189	33	13	6.8	4.9	2.7	0.27
2021	8,372	2,093	324	172	30	11	6.2	4.5	2.5	0.25
2022	26,266	6,568	1,012	537	93	36	19	14	7.8	0.78
2023	31,573	7,894	1,232	654	114	44	24	17	9.5	0.95
2024	52,479	13,122	2,023	1,074	187	72	39	28	16	1.6
2025	6,252	1,563	248	132	23	8.8	4.8	3.4	1.9	0.19
2026	24,978	6,245	973	517	90	34	19	13	7.5	0.75
2027	9,844	2,461	390	207	36	14	7.5	5.4	3.0	0.30
2028	11,922	2,981	465	247	43	16	8.9	6.4	3.6	0.36
2030	10,202	2,551	405	215	37	14	7.8	5.6	3.1	0.31
2031	13,527	3,382	537	285	50	19	10	7.4	4.1	0.41
2032	32,775	8,195	1,268	673	117	45	24	18	9.8	0.98
2033	20,675	5,170	800	425	74	28	15	11	6.2	0.62
2034	34,307	8,578	1,340	711	124	47	26	19	10	1.0
2035	27,206	6,802	1,062	564	98	38	20	15	8.2	0.82
2036	46,335	11,585	1,797	954	166	64	35	25	14	1.4
2037	17,730	4,433	704	374	65	25	14	9.8	5.4	0.54
2038	6,229	1,558	244	129	23	8.6	4.7	3.4	1.9	0.19
2039	13,847	3,462	539	286	50	19	10	7.5	4.1	0.41
2040	3,634	909	144	77	13	5.1	2.8	2.0	1.1	0.11
2043	9,556	2,389	380	201	35	13	7.3	5.3	2.9	0.29
2044	5,896	1,474	234	124	22	8.3	4.5	3.2	1.8	0.18
2045	3,564	891	142	75	13	5.0	2.7	2.0	1.1	0.11
2046	2,947	737	117	62	11	4.1	2.3	1.6	0.90	0.090
2047	917	229	35	19	3.2	1.2	0.67	0.49	0.27	0.027
2049	2,928	732	116	62	11	4.1	2.2	1.6	0.89	0.089
2052	1,809	452	72	38	6.6	2.5	1.4	0.99	0.55	0.055
2056	3,255	81,414	129	69	12	4.6	2.5	1.8	0.99	0.10
2057	3,255	814	129	69	12	4.6	2.5	1.8	1.0	0.10
2058	4,820	1,205	184	98	17	6.5	3.5	2.6	1.4	0.14
Total[a]	469,490	117,389	18,304	9,715	1,690	648	352	253	141	14

Note: Adapted from Table A-84

[a] Totals may differ from sum of listed amounts due to roundoff.

ORNL Tower Shielding Facility Clean Material Recycle. Clean material sold for recycle/reuse included 30 tons of aluminum, 50 tons of steel, 5 tons of graphite, 40 tons of lead, 85 tons of miscellaneous metal, and 305 tons of concrete. Approximately 30 tons of concrete and 3 tons of activated stainless steel were transferred to the High Flux Isotope Reactor facility for reuse. Total DOE project waste avoidance was 497.2 t, with a cost avoidance of $2,766,000 in FY1998.

Sale of LLW Drums. In FY1998, DOE processed the LLW contained in a number of drums. Since the empty drums were contaminated, they where sold to a commercial vendor for like use (i.e. supercompaction of LLW). The total project waste avoidance to DOE was 54 t and the cumulative cost avoidance to DOE and industry was $178,000.

B-25 Boxes. In FY1998, 35 boxes have been shipped to ETTP for reuse on a re-industrialization project. This represents a waste and cost avoidance of 13 t and $10,500 to DOE.

ETTP Three Building D&D and Recycling Project. BNFL Inc. was awarded a $238 million fixed price contract on 25 August 1997 to deliver vacant and decontaminated buildings (K-29, K-31, and K-33) to DOE/ORO. The $238 million contract cost included a credit back to DOE of $55,569,748 for the recyclable material. This amounts to quarterly cost savings of $2,646,178 over 21 quarters for the materials recycled or reused. The recycling activities began in the fourth quarter of CY1998 and were scheduled to continue throughout the duration of the contract (but see Note 1). The scheduled end date is 31 December 2003.

The following materials were recycled in the fourth calendar year quarter of 1998 for a cost savings for this quarter of $2,646,178:

- Lube Oil, Hazardous, 83 t
- Transformers, MLLW, 119 t
- Scrap Metal, LLW, 395 t

Approximately 117,162 t of material were to be recycled from the three buildings, including 70,232 t from K-33, 12,138 t from K-29, and 34,792 t from K-31.

ETTP K-31 & K-33 Switchyard. DOE has elected to fund Option I under the BNFL ETTP Three-Building D&D and Recycle Project. The equipment removal activities also included the disposition of the equipment as salvage/recycle materials and the disposal of all waste. The switchyard materials and equipment are non-radioactive. The estimated total mass of all equipment and materials awaiting disposition is 3,673 t. The dismantlement work began July 14, 1998. Total project savings are estimated at $1,103,833. As of December 1998, 1,049 t of clean scrap metal from the ETTP Switch Yard had been recycled.

SEG Bear Creek Facility. In 1996 INEEL shipped about 46,000 lb (~21 t) of radiologically contaminated scrap to SEG for melting and beneficial reuse (INEEL 1997). The INEEL material was scheduled to be remelted into shielding blocks for use at LANL. The slag was to be returned to INEEL for disposal.

In April 1997, GTS Duratek acquired SEG and announced in June of that year that staff reductions would be made (GTS 1997b). They noted that the flow of contaminated material to the Metal Melt Facility was neither sufficient nor steady enough to maintain continuous operations. GTS Duratek notes that the SEG facility (a 20-ton, 7,200 kW electric induction furnace) is the largest low-level radioactive metal furnace in the United States and the only one capable of making 10-ton shield blocks for DOE. Since 1992, SEG has converted over 60 million pounds of metal into shield blocks, each weighing 1 - 10 tons, for use at DOE laboratories (GTS 1997a).

Other Activities. Approximately 26,000 lb (~12 t) of slightly contaminated lead from INEEL was mixed with other metal provided by Lockheed Martin Energy Systems and used to manufacture ten lead-lined shielded storage containers at Manufacturing Sciences Corporation in Oak Ridge, Tenn. The storage containers are being used at the INEEL Radioactive Waste Management Complex to store remote-handled TRU waste (INEEL 1998).

4.3.2 Activities of Members of the Association of Radioactive Metal Recyclers (ARMR)

ARMR member companies are responsible for the great majority (over 80%) of residually radioactive scrap metals in the United States that are either recycled or reused, in accordance with established NRC/DOE/State guidelines. Activities of the ARMR between 1995 and 1998 are summarized below (Loiselle 1999).

1995 About 15,000 t of RSM were surveyed and then either free-released or melted into shield blocks. The split was approximately one-half for each path (release or melt). Approximately 6,000 t of this metal originated in commercial nuclear utilities, another 6,000 t from the DOD. (The latter metal made into shield blocks). The remainder was from DOE.

1996 About 13,000 t were surveyed and then either free released, melted into shield blocks, or used to fabricate boxes and drums for restricted uses. Approximately 6,000 t, which came from the DOD, were made into shield blocks, 700 t from DOE were converted into restricted use boxes and drums, and most of the remainder was from the nuclear utilities.

1997 About 9,000 t from nuclear utilities were surveyed and free released. During this year, DOE did not release any metals to ARMR members, and no metal melting was required.

1998 About 20,000 t were surveyed and 17,000 t were free-released. The remaining 3,000 t were DOD metals that were melted into shield blocks. Approximately 10,000 t of the 17,000 t of the free-released scrap metal came out of the BNFL Three Building Project. The remainder was from nuclear utilities.

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